

## VERA Geodetic Activities

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### Abstract

This report describes the status of the VERA network in the context of geodetic VLBI. The main contents are information about its technical parameters and a summary of its geodetic VLBI activities during 2008.

### 1. General Description

VERA is a Japanese domestic VLBI network operated by Mizusawa VERA Observatory, NAOJ. The network consists of four stations which are Mizusawa, Iriki, Ogasawara, and Ishigakijima. Each station is equipped with a 20m radio telescope and a VLBI data acquisition system. The observing frequency bands of VERA are S and X, K (22 GHz), and Q (43 GHz). The Ogasawara antenna is shown in Figure 1. The VERA array is controlled from the Array Operation Center at Mizusawa via the Internet.

VERA determines the positions of Galactic maser sources relative to extragalactic radio sources by phase reference VLBI observation. The goal for the accuracy of the annual parallaxes and proper motions determined from time series analyses of the maser sources' positions is the 10 microarc-second level. Regular astrometric observations have continued since 2003. The annual parallaxes of some radio sources are presently estimated with a precision on the order of 10 microarcseconds (recent result from VERA, PASJ Vol. 60, No. 5, 2008).

Geodetic observations with VERA started in late 2002 and have been done routinely since late 2004. Monitoring of the positions and the movements of the VERA antennas by geodetic observations contributes to maintaining the accuracy of VERA astrometric measurements. Geodetic observations are made in the S-, X-, and K-bands.

General information about the VERA stations is summarized in Table 1, and the geographic locations are shown in Figure 2. The lengths of the baselines range from 1000 km to 2272 km.

VERA contributes to lunar exploration. VLBI observations to determine the orbit of the "KAGUYA" satellite began in the winter of 2007 and continue now. The total number of observing days is about seven every month. The S/X receiving and transmission system is shared between geodetic and KAGUYA observations.

Table 1. General information

Sponsoring agency	Mizusawa VERA Observatory, National Astronomical Observatory of Japan	
Contributing type	Network observing station	
Location	Mizusawa	141° 07' 57".2E, 39° 08' 00".7N, 75.7m (a.s.l.)
	Iriki	130° 26' 23".6E, 31° 44' 52".4N, 541.6m (a.s.l.)
	Ogasawara	142° 12' 59".8E, 27° 05' 30".5N, 223.0m (a.s.l.)
	Ishigakijima	124° 10' 15".6E, 24° 24' 43".8N, 38.5m (a.s.l.)

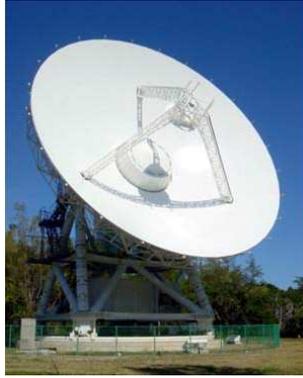


Figure 1. The VERA Ogasawara antenna which is located in Chichijima Island.

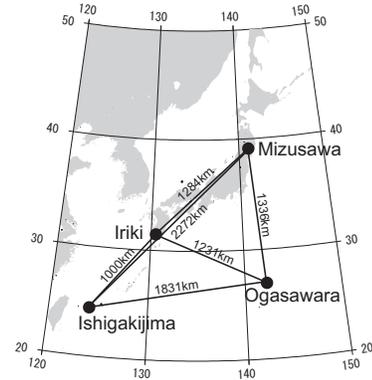


Figure 2. Locations of VERA stations.

Table 2. Antenna parameters

Diameter	20m		
Mount	Azimuth–Elevation		
Surface accuracy	0.2mm (rms)		
Pointing accuracy	<12" (rms)		
	S	X	K
HPBW	1550"	400"	150"
Aperture efficiency	0.25	0.4	0.47
Slew	Azimuth		Elevation
range	-90°–450°		5°–85°
speed	2°.1/sec		2°.1/sec
acceleration	2°.1/sec <sup>2</sup>		2°.1/sec <sup>2</sup>



Figure 3. DIR2000  
1 Gbps recorder used in VERA.

## 2. Technical Parameters

Parameters of the antennas and the front- and back-end systems are summarized in Tables 2 and 3, respectively. The 1 Gbps recorder named DIR2000 is shown in Figure 3.

## 3. Geodetic VLBI Observing Activities

Two observation modes are used for geodetic observations. One is the VERA internal geodetic observing mode. During 2008, VERA internal geodetic observations were carried out 17 times. K-band was used in all VERA internal geodetic observations. Compared to 2007, the number of observations decreased because some observing was cancelled to perform maintenance on the antennas and recorders.

The other observing mode is Mizusawa's joint observing with the Geographic Survey Institute (GSI) within GSI's domestic observing sessions, JADE. The purpose of the JADE participation is to have VERA's coordinates connected via Mizusawa to the terrestrial reference frame realized by

Table 3. Front-end and back-end parameters

front-end					
Frequency band	Frequency range(GHz)	Receiver temperature	Polarization	Receiver type	Feed
S	2.18–2.36	100K	RHC	HEMT	Helical array
X	8.18–8.60	100K	RHC	HEMT	Helical array
K	21.5–24.5	39±8K	LHC	HEMT(cooled)	Horn
back-end					
Type	channels	BW/channel	Filter	Recorder	Deployed station
VERA	16	16MHz	Digital	DIR2000	4 VERA
K5-VSSP	16	4MHz	VC	HDD	Mizusawa

the IVS. Mizusawa's frequency band is S/X, and its recording rate is 128 Mbps. A K5-VSSP data acquisition terminal is used. Mizusawa took part in JADE seven times during 2008.

Use of the 1 Gbps recording mode continued in 2008 according to the JADE schedule at all VERA stations and at Tsukuba. The raw observation data was sent from the Tsukuba 32 m antenna via G-bit optical fiber network and was recorded with the 1 Gbps recording system at the Mitaka FX Correlation Center. All VERA antennas were connected with the IVS network directly due to this observation mode. This observation mode was used four times during 2008, but only one session could be analyzed because of the instability of the clock in the data transmission system between Tsukuba and Mitaka.

#### 4. Earthquake

At 8:43 on June 14, 2008 (JST), the Iwate Miyagi Nairiku Earthquake (M 7.2) occurred. The epicenter's distance and direction from the VERA Mizusawa station was about 20 km WSW. The type of fault was reverse. The seismic intensity at the Mizusawa station was 5+ on the JMA seismic intensity scale. (The maximum is 7.) The west side of Oshu City suffered great damage. Due to co-seismic and post-seismic crustal movements, the VERA Mizusawa antenna moved downward by about 1 cm and westward by about 9 cm. Co-seismic steps in the coordinates obtained from continuous GPS observations are shown in Figure 4. The Mizusawa GPS station that detected the co-seismic steps is shown in Figure 5.

#### 5. Staff Members

The VERA team of NAOJ consists of nine scientists, seven technicians, and four post-docs. Among them, the members of the geodesy group are S. Manabe (chief, scientist), Y. Tamura (scientist), T. Jike (scientist), and M. Shizugami (software technician).

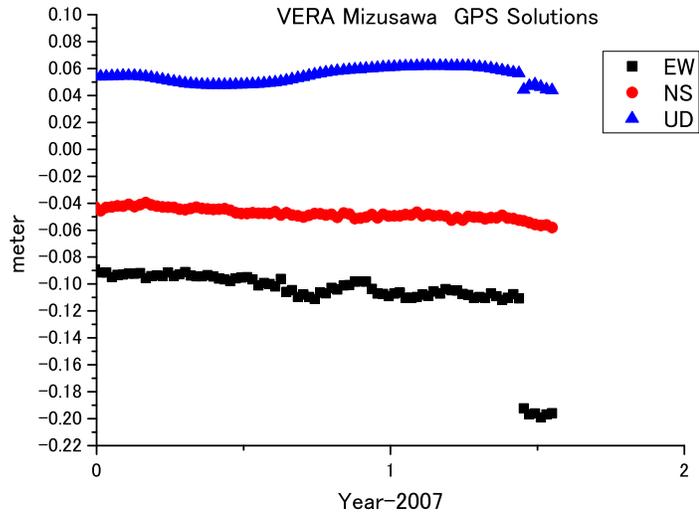


Figure 4. Movement of the Mizusawa GPS station caused by the Iwate Miyagi Nairiku Earthquake.

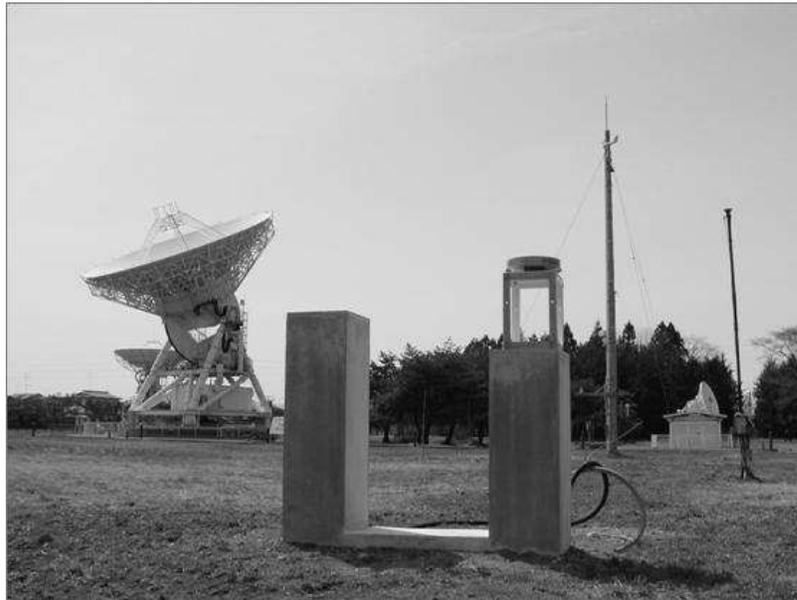


Figure 5. The Mizusawa GPS station under construction in 2006.